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Dunn et al.

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(54) **BACKLIGHT ADJUSTMENT SYSTEM**

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Related U.S. Application Data

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G09G 3/36 (2006.01)
H05B 33/08 (2006.01)

(52) **U.S. Cl.**

CPC ***H05B 33/0854*** (2013.01); ***H05B 37/02*** (2013.01)

(58) **Field of Classification Search**

USPC 315/149–159, 224, 291, 294, 307, 308, 315/309, 312; 345/102

See application file for complete search history.

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(57) **ABSTRACT**

A preferred embodiment relates to controlling the amount of backlight power in an electronic display to account for the temperature in the backlight cavity. Another embodiment relates to a system for controlling the amount of backlight based on both the temperature of the backlight and the amount of ambient light.

12 Claims, 6 Drawing Sheets

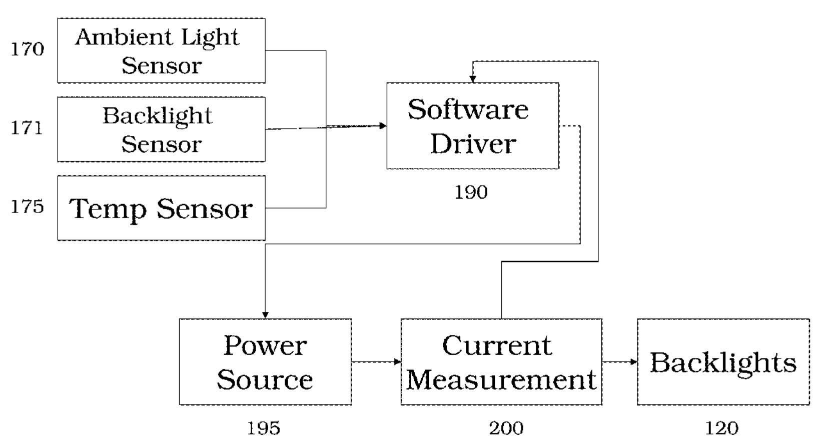

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Figure 1

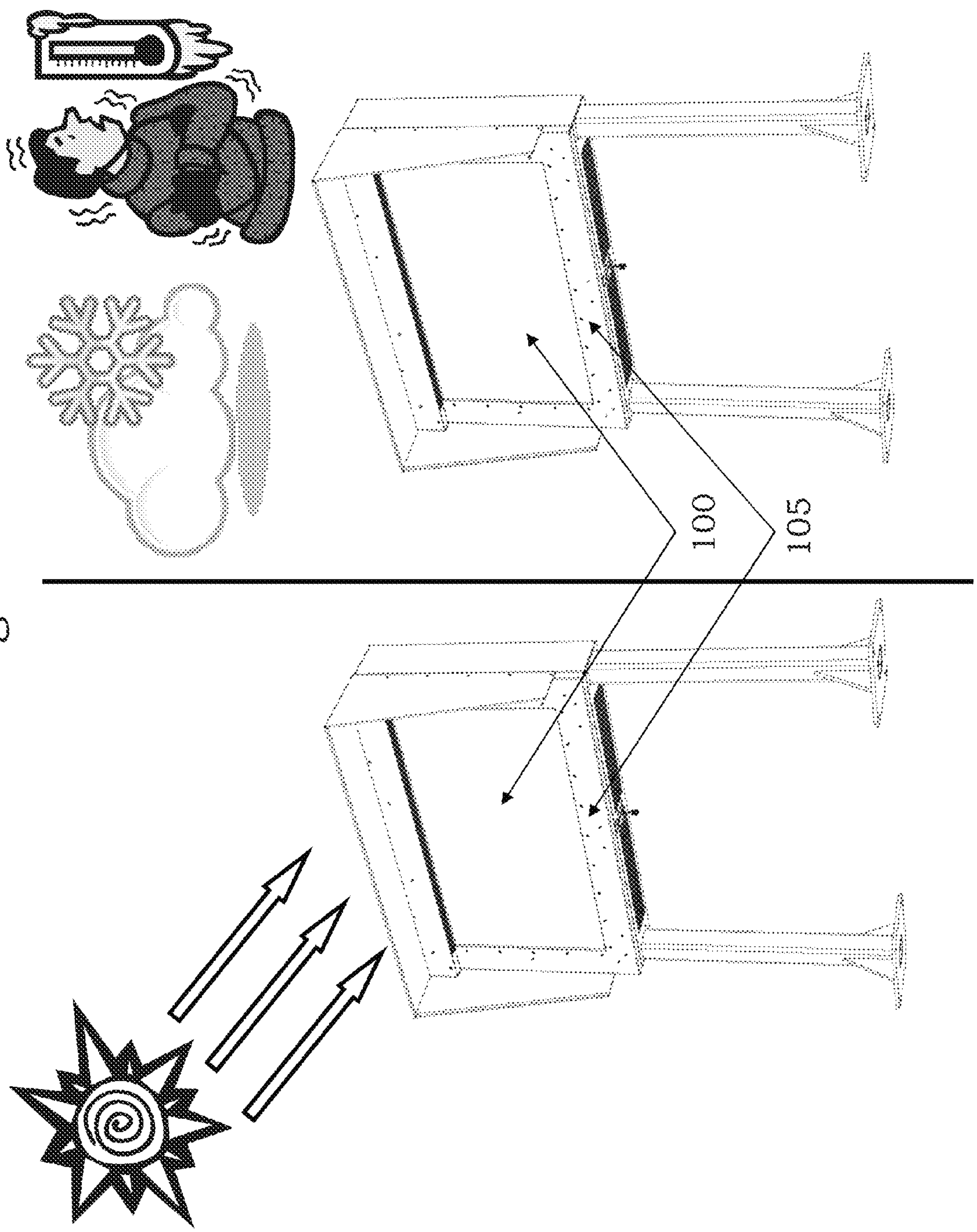


Figure 2

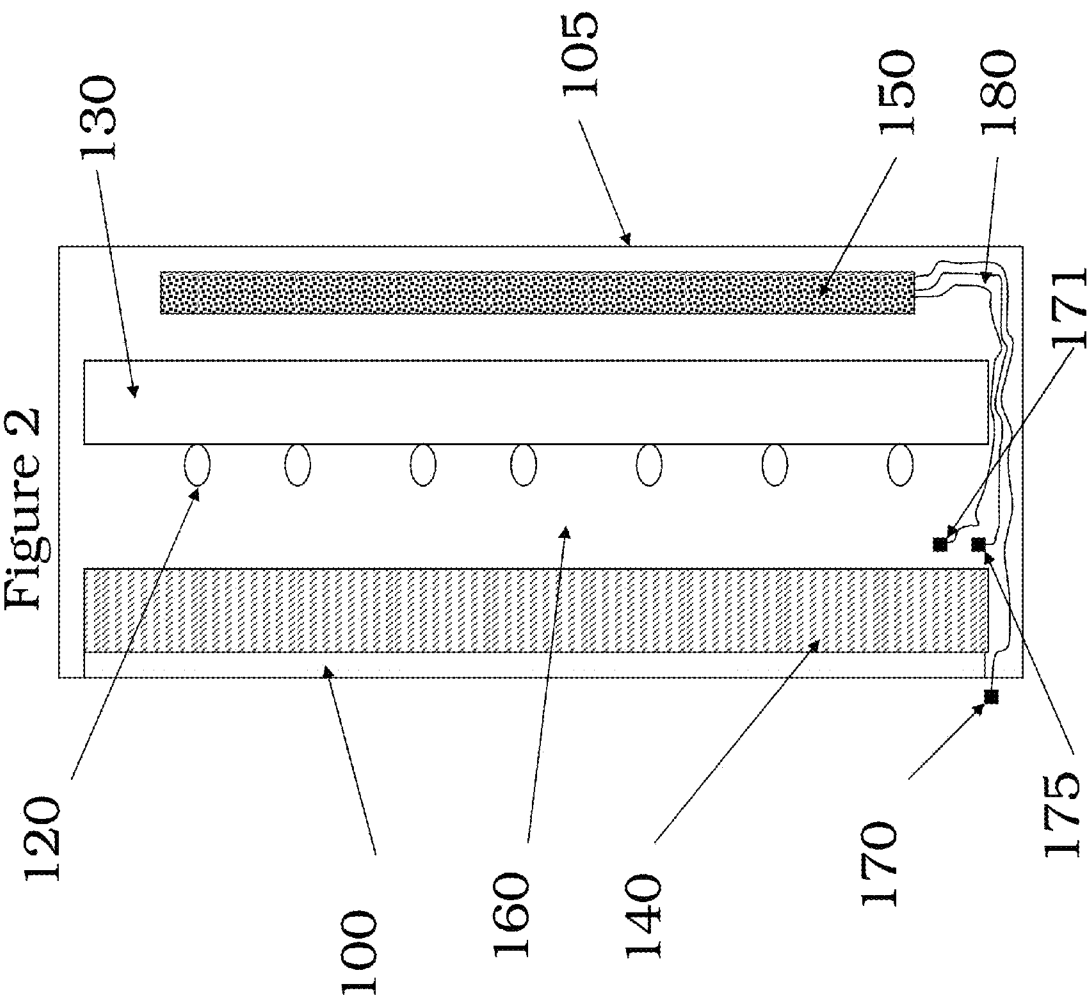
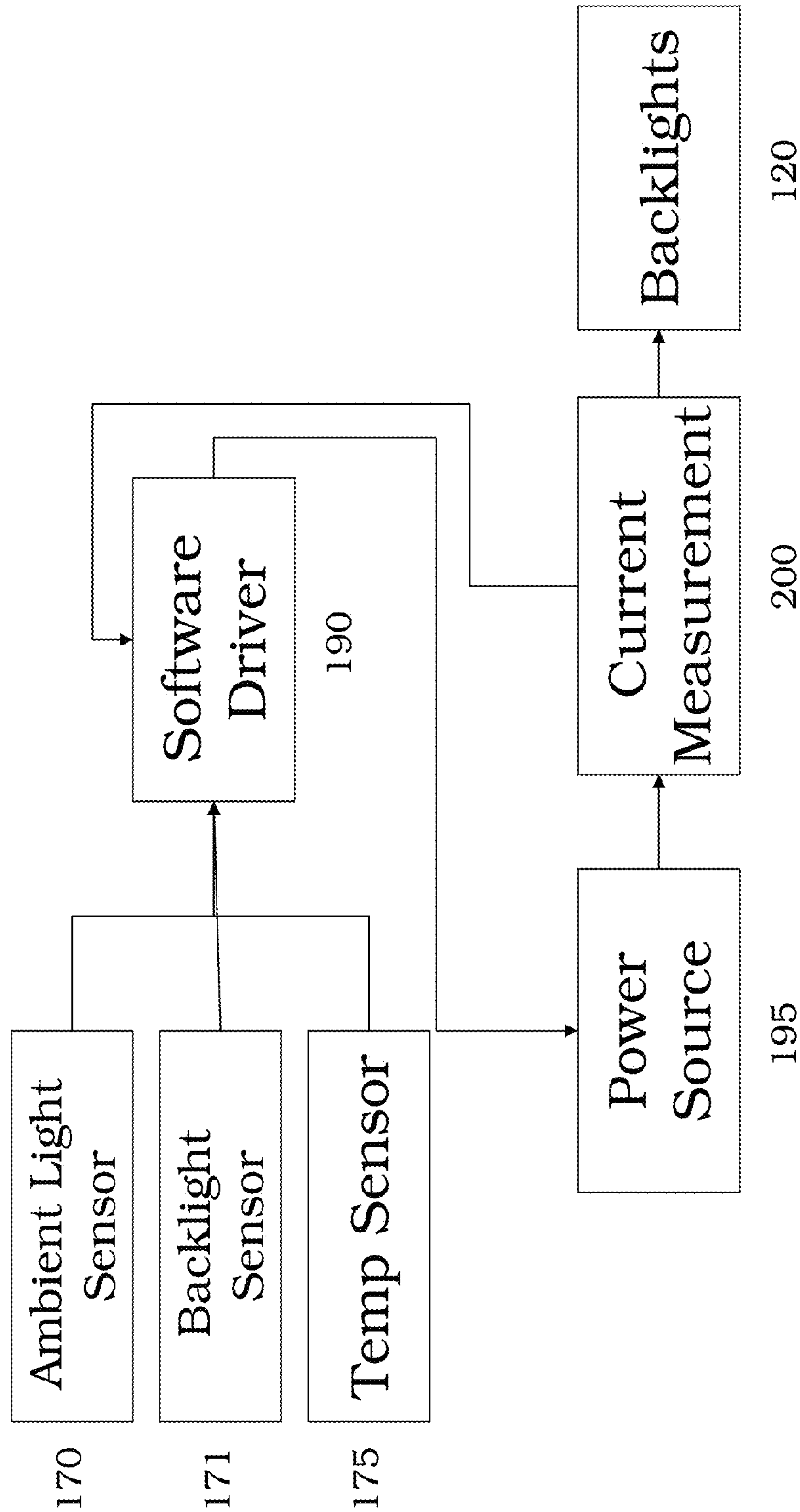


Figure 3


Ambient Light Sensor
170
Backlight Sensor
171
Temp Sensor
175
Software Driver
190
Power Source
195
Current Measurement
200
Backlights
120

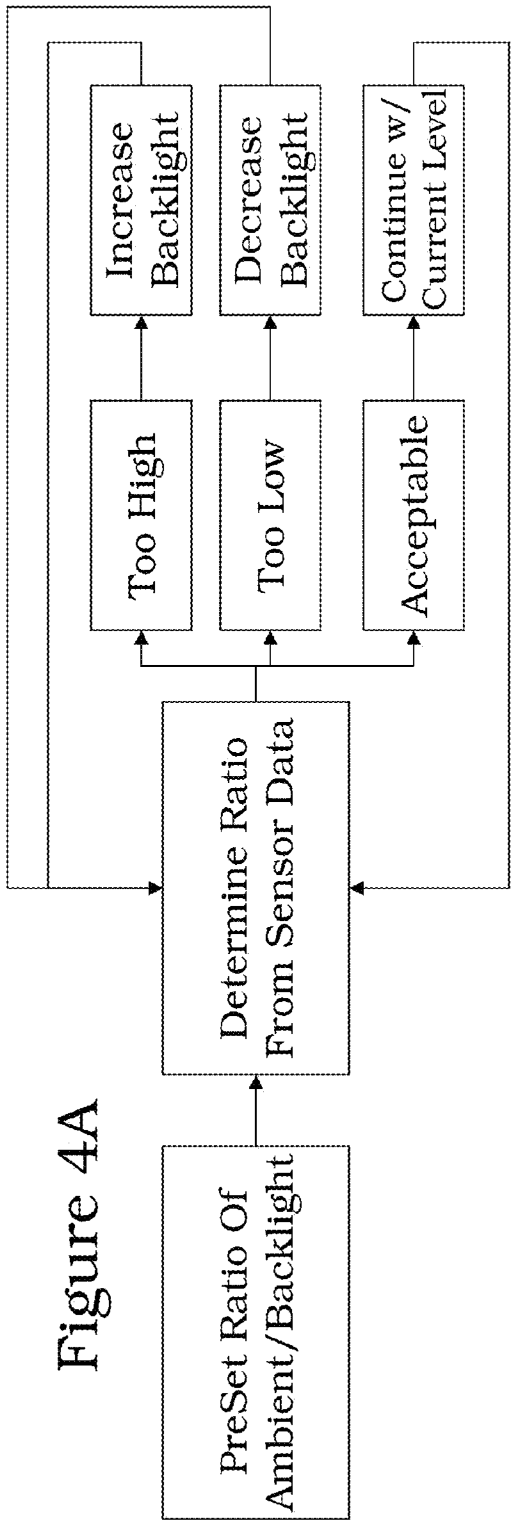


Figure 4A

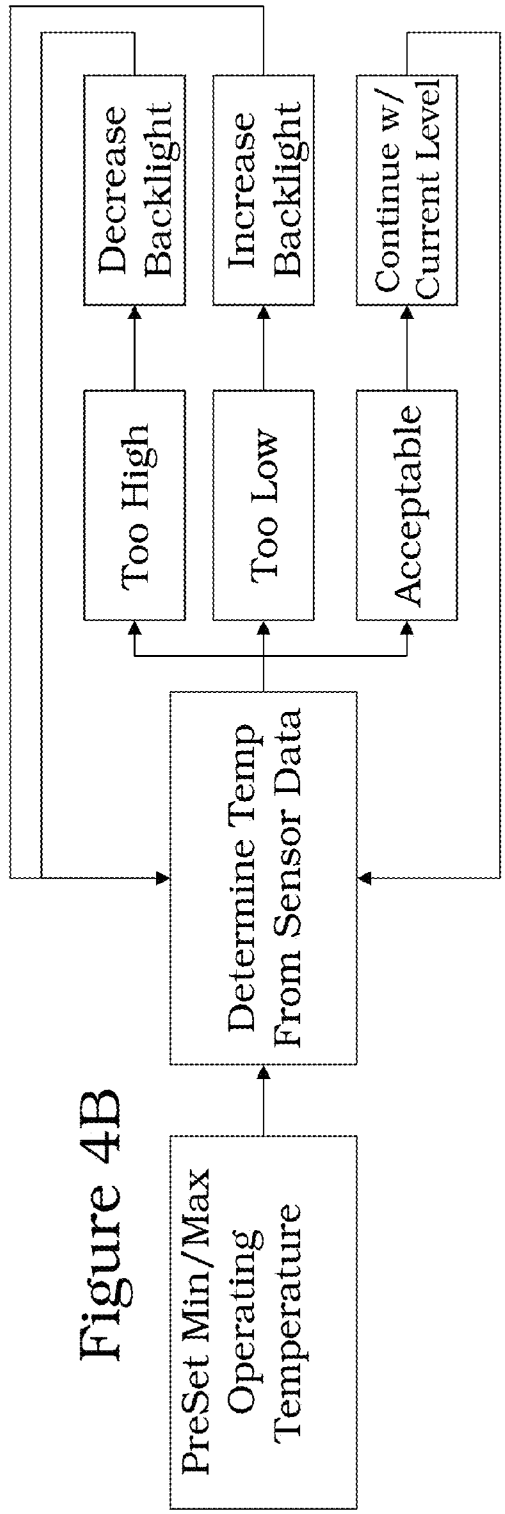


Figure 4B

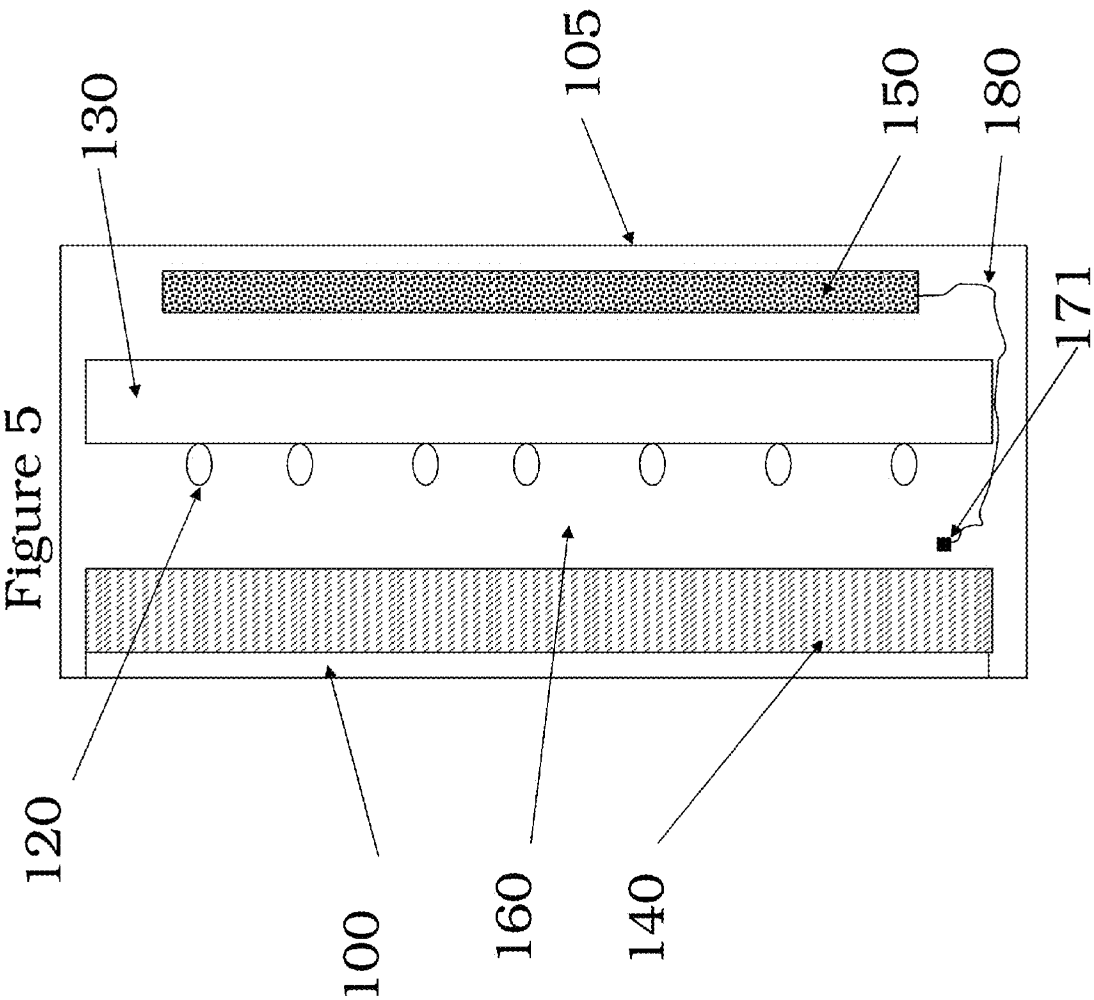
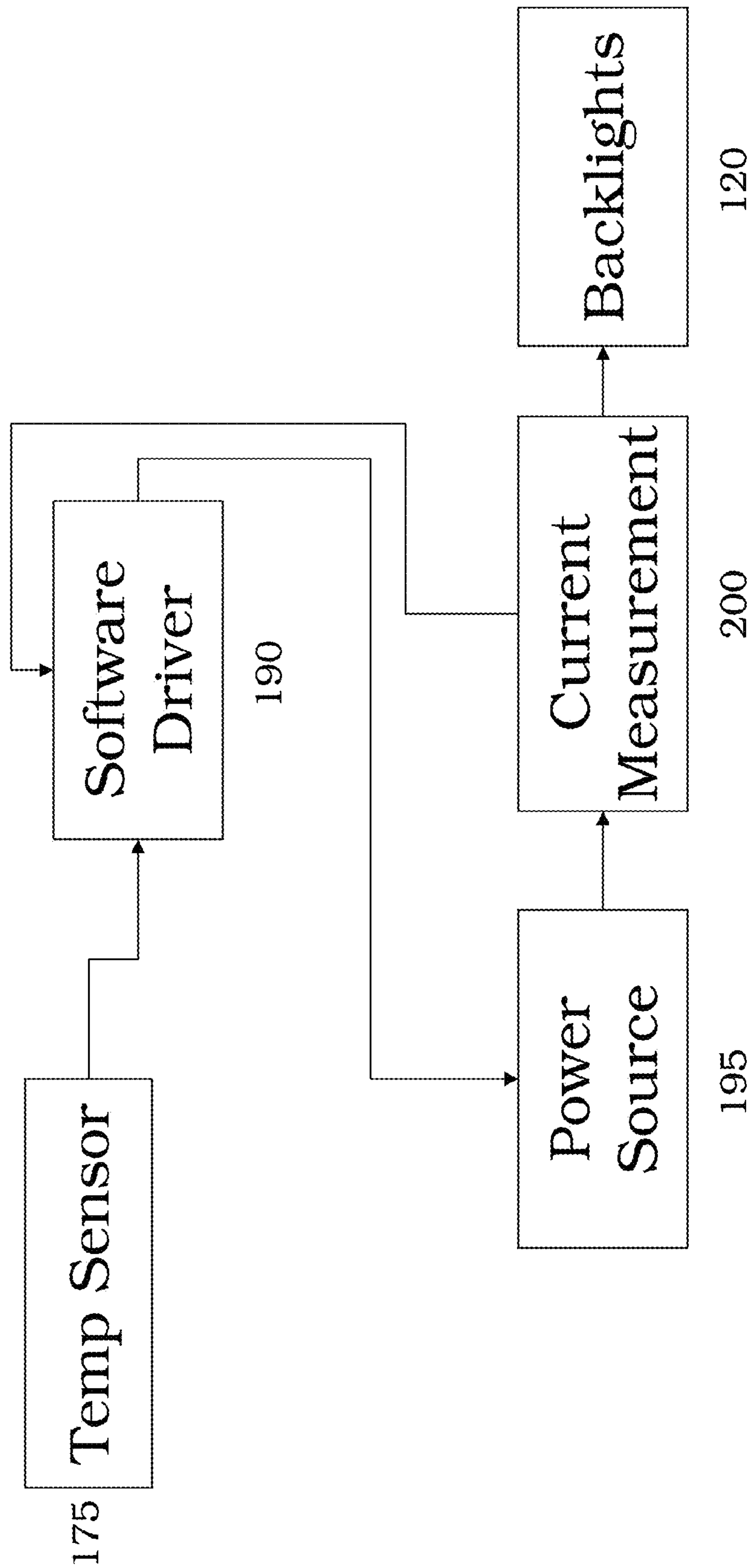


Figure 5

Figure 6


Temp Sensor
175
Software Driver
190
Power Source
195
Current Measurement
200
Backlights
120

BACKLIGHT ADJUSTMENT SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of and claims priority to U.S. application Ser. No. 14/447,164 filed on Jul. 30, 2014 now issued U.S. Pat. No. 9,030,129 which is a continuation of U.S. application Ser. No. 13/353,371 filed on Jan. 19, 2012 now issued U.S. Pat. No. 8,829,815 which is a continuation of U.S. application Ser. No. 12/124,741 filed on May 21, 2008 now issued U.S. Pat. No. 8,125,163, all of which are herein incorporated by reference in their entirety.

TECHNICAL FIELD

This invention generally relates to electronic display sensor systems and in particular to adjustable backlight systems for advanced electronic displays.

BACKGROUND OF THE ART

Traditionally, advanced electronic display systems have only been used for indoor applications, or outdoor applications where the variation in temperature and/or amount of direct sunlight is limited. When these systems are moved outside, both elements become significant factors in the display's ability to accurately recreate an image.

Cold is especially harmful to liquid crystal display (LCD) systems where the crystals can actually freeze. Heat is also harmful to many electronic displays as the electrical components which drive the display system may overheat and malfunction. Further, direct sunlight can limit the visibility of the display, as the reflection of the sun off of the viewing surface may be brighter than the light which is generated by the display. Direct sunlight can also heat the display, contributing to the overheating of electrical components or possible damage to liquid crystals in LCD applications.

SUMMARY OF THE INVENTION

Exemplary embodiments include a system and method for adjusting the backlighting on an electronic display based on temperature and luminance measurements. Electronic displays typically contain some type of light source in order to generate an image on the display screen. This light source is often referred to as the display's backlight. Sometimes, fluorescent bulbs may be used or more preferably, light emitting diodes (LED). A backlight system using LED's is disclosed in U.S. Pat. No. 7,052,152, herein incorporated by reference.

The amount of light that is required from a display backlight is dependent upon the amount of ambient light that is coming from the surrounding environment. For example, when the surrounding environment is very bright, a large amount of light is required from the backlight, as this light must overcome the bright light which is in the environment and is reflecting off the display surface. In contrast, when the surrounding environment is very dark, only a small amount of light is required from the backlight, as the display's light does not have to compete with a bright ambient light.

For indoor display applications, the variance is amount of backlight may be relatively low, as the amount of light inside a room may vary only a small amount. However, when electronic displays are used outdoors, the amount of ambient light can vary drastically. The ambient light that is surrounding the display can vary anywhere from completely dark at night, to being in direct sunlight during the day. These concerns are amplified for advanced displays which are designed to produce high quality, bright images with sharp contrast. Thus, in an exemplary embodiment the backlight of an electronic display is controlled, depending at least upon the amount of ambient light.

Some sources of backlighting degrade over time. For example, LED's may degrade over time and emit less light. Exemplary embodiments also allow for the brightness of a display to adjust based on the degradation of the light source.

Also for indoor applications, the temperature that an electronic display is subjected to will also vary only a small amount. Typically, these displays only see a range of temperatures near room temperature (ex. 65-75 degrees Fahrenheit). However, for outdoor applications, displays will see a very wide range of temperatures. These displays may see temperatures ranging from well below freezing to well over 100 degrees Fahrenheit.

The electronic display backlight is also a significant source of heat for the display. As mentioned above, too much heat or too little heat can also damage or destroy an electronic display. Again, this is especially a problem for large advanced displays, as these devices typically are required to produce bright, clear images. The amount of light that is required, typically forces the backlighting assembly to produce a large amount of light, which typically produces a large amount of heat. Thus, exemplary embodiments also control the level of the display backlighting based on the temperature of the air within the backlight cavity.

The foregoing and other features and advantages of the present invention will be apparent from the following more detailed description of the particular embodiments, as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

A better understanding of an exemplary embodiment will be obtained from a reading of the following detailed description and the accompanying drawings wherein identical reference characters refer to identical parts and in which:

FIG. **1** is a perspective view of an exemplary electronic display.

FIG. **2** is a side plan view of an exemplary embodiment showing components of the display system and the control system.

FIG. **3** is a flow chart showing the components for an exemplary embodiment of the control system.

FIG. **4**A is a flow chart showing the logic for controlling the amount of backlight based on the amount of ambient light.

FIG. **4**B is a flow chart showing the logic for controlling the amount of backlight based on the temperature in the backlight cavity.

FIG. **5** is a side plan view of another embodiment where the amount of backlighting is not based on the ambient light.

FIG. **6** is a flow chart showing the components for another embodiment where the amount of backlighting is not based on the ambient light.

DETAILED DESCRIPTION

Exemplary embodiments include a system and method for adjusting the backlighting on an electronic display based on temperature and luminance measurements.

FIG. **1** shows an exemplary outdoor display which could be subjected to high levels of both heat and cold. The viewing surface **100** is contained within the display housing **105**.

FIG. **2** shows further details about the electronic display and its associated components. The display housing **105** may contain all of the associated components. The viewing surface **100** is again found on the front of the display housing **105**.

Towards the back of the display housing **105** is the electrical devices **150** which run the display. These devices may include: motors, circuit boards, resistors, capacitors, wiring, electronic chips, heating/cooling elements, fans, and power sources. In front of the electrical devices **150** is the backlight panel **130** and the backlight **120**. In this exemplary embodiment, the backlight **120** comprises LED's, but any form of illumination will still fall within the scope of the invention. The backlight panel **130** provides a mounting surface for the LED's. The backlight panel **130** may also contain a highly reflective front surface so that the maximum amount of light from the LED's can pass through the viewing surface **100**.

Between the backlight **120** and the viewing assembly **140** is the backlight cavity **160**. The dimensions of the backlight cavity **160** is typically a function of the number of backlight LED's **120** and their luminance, size of the viewing surface **100**, and the properties of the viewing assembly **140**. The viewing assembly **140** may contain a variety of elements which are used to generate an image upon the viewing surface **100**. In an LCD display for example, the viewing assembly **140** may contain a light diffuser, light reflector, several layers of polarizing glass, and a liquid crystal assembly. The precise elements and their arrangement will vary depending on the specific electronic display device being used and its particular application.

In an exemplary embodiment, an ambient light sensor **170** may be located outside of the display housing **105** and in front of, but not blocking the display surface **100**. This ambient light sensor **170** measures the amount of light which is contacting the front surface of the display housing **105**. Although shown at the base of the display in FIG. **2**, the ambient light sensor **170** can be placed anywhere the sensor can measure the light contacting the front of the display housing **105**, and near the display surface **100**.

A backlight sensor **171** may be placed within the backlight cavity **160**, and measures the amount of light which is luminating from the backlight **120**. The backlight sensor **171** can be placed anywhere within the backlight cavity **160**, but preferably should be oriented so that it does not block any significant amount of light from entering the viewing assembly **140**.

Further in this exemplary embodiment, a temperature sensor **175** may be located within the backlight cavity **160**. This temperature sensor **175** also can be located anywhere within the backlight cavity **160** or anywhere inside the display housing **105**, but preferably should be oriented so that it does not block any significant amount of light from entering the viewing assembly **140**. The wiring **180** for the three sensors is shown at the base of the display housing **105** and running back to the electronic devices **150**. The wiring **180** can be oriented in a number of ways, with or without separate connectors, as is common for one skilled in the art.

FIG. **3** shows an exemplary embodiment with associated components and their connectivity. Data from the ambient light sensor **170**, backlight sensor **171**, and temperature sensor **175** flows into the software driver **190**. The software driver **190** may be any commercially available control system or microcontroller. Preferably, the software driver **190** comprises an e^{2}prom (or eeprom), which is commercially available from Digi-Key (www.digi-key.com). The logic for the software driver is discussed below, under FIGS. **4**A and **4**B.

The software driver **190** decides how much power to send to the backlight **120**. The software driver **190** sends the data regarding the proper amount of power to the power source **195**, which generates the proper amount of power. A current measurement device **200** may be used to measure the amount of power coming from the power source **195**. This information is sent back to the software driver **190** and compared to the power data which was originally sent to the power source **195** in order to ensure that the proper amount of power was in fact sent to the backlight **120**. If these values do not match, adjustments are made by the software driver **190**. Although this embodiment shows a current measurement device, any type of power measurement device will suffice.

Finally, the power is sent to the backlight **120**, where the amount of light generated is again measured by the backlight sensor **171**. The data from the backlight sensor **171** is again sent to the software driver **190**, along with the data from the ambient light sensor **170** and the temperature sensor **175** as the process is repeated.

FIG. **4**A shows an exemplary embodiment for the logic contained in the software driver **190** for adjusting the backlight based on the amount of ambient light. Ideally, a preferred light ratio can be determined which compares the amount of light in the ambient surroundings with the amount of light being generated in the backlight cavity **160**. For most applications, the amount of backlight will need to be greater than the amount of ambient light to ensure that the display can be seen. Preferably, the ratio of ambient light to backlight should be less than one. (ex. Ratio=ambient light/backlight). However, the precise ratio can vary depending on the particular display, environment, and application.

After a preferred light ratio is selected, it is stored within the software driver **190**. The light ratio will also likely have an acceptable range, such that there is an ideal ratio with a certain amount of tolerance which allows the measured ratio to drift above or below the ideal ratio, before any action is taken by the system. The software driver **190** then reads the data from the light sensors and calculates the current light ratio. If the ratio is outside of the accepted tolerance range, then the system takes action. If the ratio is too low (i.e. there is too much backlight for the amount of ambient light), the backlight is decreased. If the ratio is too high, the backlight is increased. If the ratio is within the accepted tolerance, the current power to the backlight is continued.

FIG. **4**B shows an exemplary embodiment for the logic contained in the software driver **190** for adjusting the backlight based on the temperature in the backlight cavity **160**. A preferred operating temperature can be selected for the display, which will take into account the type of display, application, and its environment. This preferred operating temperature would again have a tolerance, where there is a minimum acceptable temperature along with a maximum acceptable temperature. The software driver **190** determines the current temperature from the temperature sensor **175** and compares this value to the preset min/max operating temperature. If the present value is below the minimum, the backlighting is increased to facilitate the warming of the display. If the present value is above the maximum, the backlighting is decreased to facilitate the cooling of the display. If the present value is within the acceptable range, the present amount of power to the backlighting will be continued.

Using the amount of backlighting to facilitate the warming or cooling of an electronic display is very useful in applications where the display is exposed to a wide range of temperatures, especially high levels of cold or heat. For example, in an outdoor application where the temperature of the ambient air becomes very warm (and subsequently warms the temperature of the air in the backlight cavity **160**) the display may become damaged if it continues to run. In typical displays, a thermostat will simply turn the display off to allow it to cool. However, where a display is used as an advertisement tool or for displaying important information, turning off the display will result in a lack of communication of any images whatsoever. Exemplary embodiments allow the display to simply dim itself slightly, to allow the unit to cool while still providing some visible image (albeit not as bright, but still visible).

This function also aids in protecting a display when the ambient air becomes very cold (and subsequently cools the air in the backlight cavity **160**). Exemplary embodiments allow the display to increase the amount of backlighting, which will typically produce more heat, and subsequently heat the dangerously cool display.

The embodiments shown in FIGS. **2** and **3** allow the system to control the backlighting based on both the ambient light and the temperature in the backlight cavity. FIG. **5** shows another embodiment where the system controls the amount of backlighting based on the temperature in the backlight cavity, without regard to the amount of ambient light. This embodiment lacks the previous light sensors, but contains the temperature sensor **175**.

FIG. **6** shows the various components for this embodiment, again lacking the light sensors but still containing the temp sensor **175**, software driver **190**, power source **195**, current measurement **200** (optional), and backlight **120**. As the embodiments in FIGS. **2** and **3** conduct the logic in both FIGS. **4**A and **4**B, the embodiments in FIGS. **5** and **6** would only conduct the logic in FIG. **4**B.

It is to be understood that the spirit and scope of the disclosed embodiments are not limited to LCDs. By way of example and not by way of limitation, embodiments of the present invention may be used in conjunction with displays selected from among LCD (including TFT or STN type), light emitting diode (LED), organic light emitting diode (OLED), field emitting display (FED), and cathode ray tube (CRT). Furthermore, embodiments of the present invention may be used with displays of other types including those not yet discovered. In particular, it is contemplated that the present invention may be well suited for use with full color, flat panel advanced LCD displays. While the embodiments described herein are well suited for outdoor environments, they may also be appropriate for indoor applications (e.g., factory environments) where ambient light and thermal stability of the display may be at risk.

Having shown and described a preferred embodiment of the invention, those skilled in the art will realize that many variations and modifications may be made to affect the described invention and still be within the scope of the claimed invention. Additionally, many of the elements indicated above may be altered or replaced by different elements which will provide the same result and fall within the spirit of the claimed invention. It is the intention, therefore, to limit the invention only as indicated by the scope of the claims.

What is claimed is:

1. A system for controlling the backlight of an electronic display, the system comprising:
- an electronic display with a viewing surface and a backlight;
- a power source operatively connected to said backlight;
- a first light sensor to measure ambient light;
- a second light sensor to measure light emitted by said backlight; and
- a software driver operatively connected to
  - said first and second light sensors; and
  - said power source; and
- wherein the software driver is adapted to
  - receive a preferred amount of backlight illumination for a given amount of ambient light;
  - increase the power of said power source when the amount of backlight illumination is too low for the amount of ambient light; and
  - decrease the power of said power source when the amount of backlight illumination is too high for a given amount of ambient light.

2. The system of claim **1** further comprising a power measurement device operatively connected between said power source and said backlight and providing power data to said software driver.

3. The system of claim **1** wherein said software driver comprises an eeprom.

4. The system of claim **1**, wherein the backlight comprises:
- a mounting element;
- a reflective element covering one surface of the mounting element; and
- one or more illuminating devices fixedly attached to the mounting element on the surface containing the reflective element.

5. The system of claim **4**, wherein said mounting element comprises a printed circuit board.

6. The system of claim **4**, wherein said one or more illuminating devices comprise any one of the following: LED's and fluorescent lights.

7. The system of claim **1** wherein said electronic display is a liquid crystal display.

8. A method for controlling the backlight in an electronic display device having a viewing surface and backlight, the steps comprising:
- setting a maximum operating temperature for said backlight;
- defining a preferred amount of backlight illumination for a given amount of ambient light;
- measuring the temperature of the backlight;
- measuring the amount of ambient light;
- calculating a current light ratio; and
- dimming the backlight slightly when the temperature of the backlight exceeds the operating temperature range or the amount of backlight illumination is too high for a given amount of ambient light.

9. The method of claim **8** further comprising the steps of:
- measuring the amount of light generated by the backlight;
- increasing the power to the backlight when the amount of backlight illumination is too low for the amount of ambient light.

10. A method for controlling the backlight in an electronic display device, the steps comprising:
- providing an electronic display device having a viewing surface and a backlight;
- providing a power source which sends power to the backlight;
- providing a temperature sensor to measure an actual operating temperature of said display device;
- providing a driver which is operatively in communication with said power source and said temperature sensor to send electrical signals to said power source;
- establishing a preferred operating temperature range for said display device; and
- providing said electrical signals to the power source to decrease the power to the backlight when said actual operating temperature exceeds said preferred operating temperature range until the actual operating temperature returns to within the operating temperature range.

11. The method of claim **10** further comprising the steps of:
- measuring the power sent from the power source to the backlight;

comparing the power measurement to the electrical signals from the driver; and

modifying said electrical signals if said power measurement does not match said controlling signal.

12. The method of claim **10** further comprising the steps of:

measuring the amount of ambient light;

measuring the amount of light generated by the backlight;

defining a preferred amount of backlight illumination for a given amount of ambient light;

increasing the power of said power source when the amount of backlight illumination is too low for the amount of ambient light; and

decreasing the power of said power source when the amount of backlight illumination is too high for a given amount of ambient light.

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